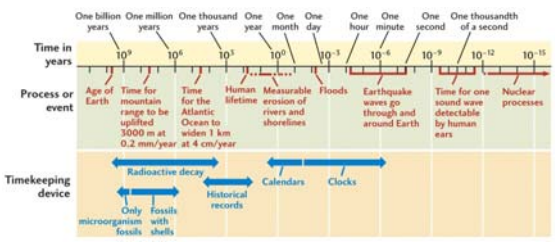
Trilobites

Geologic Time

A major difference between geologists and most other scientists is their concept of time.

A "long" time may not be important unless it is greater than 1 million years



Two Ways to Date Geologic Events

1) relative dating (fossils, structure, cross-cutting relationships): how old a rock is compared to surrounding rocks

2) absolute dating (isotopic, tree rings, etc.): actual number of years since the rock was formed

Which is older? How do you know?

http://stevengharms.com

Steno's Laws

Nicholas Steno (1669)

- Principle of Superposition
- Principle of Original Horizontality

These laws apply to both sedimentary and volcanic rocks.

Principle of Superposition

In a sequence of undisturbed layered rocks, the oldest rocks are on the bottom.

Principle of Original Horizontality

Layered strata are deposited horizontal or nearly horizontal or nearly parallel to the Earth's surface.

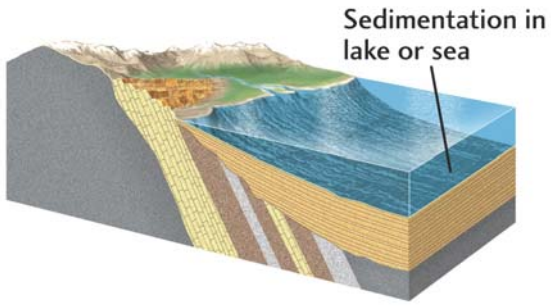


Fig. 8.4

Fig. 8.4

Paleontology

- **The study of life in the past based on the fossil of plants and animals.**

Fossil: evidence of past life

- **Fossils that are preserved in sedimentary rocks are used to determine:**
  1) relative age
  2) the environment of deposition

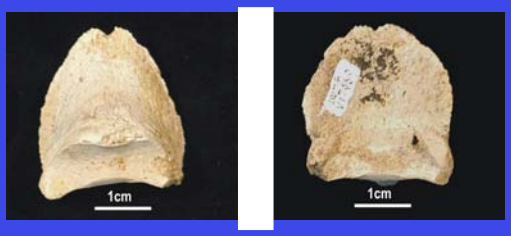
Ammonite Fossils

Petrified Forest

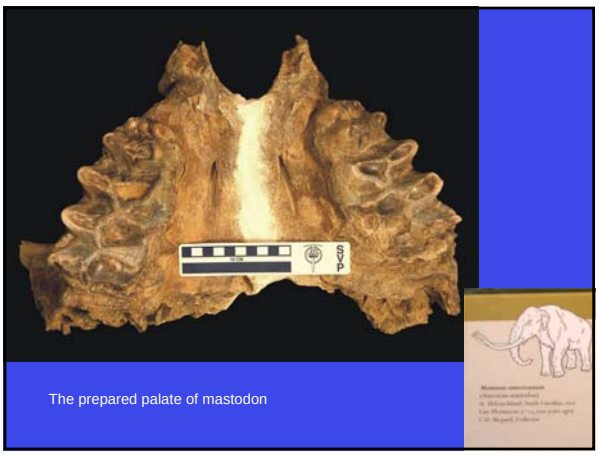
Grotzinger et al., 2007

Foraminifera, or 'forams' as they are often called, are small marine creatures that build a delicate house (called 'test') from chalk. The pyramids of Egypt are made of stone containing these creatures.

http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artmar00/forwim.html



Horse hoof. A. Dorsal view, B. Ventral view.



The prepared palate of mastodon

Correlation, Relative Age Dating, and Environment of Deposition

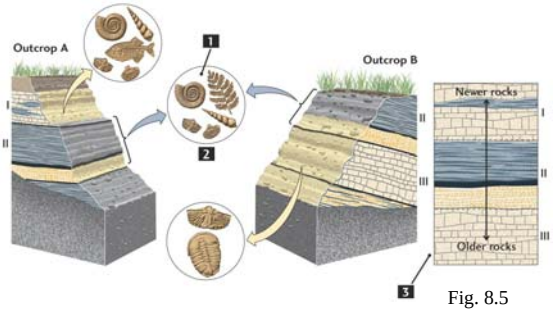


Fig. 8.5

Palynology

Study of organic-walled palynomorphs including pollen, spores, dinoflagellate cysts together with organic matter and kerogen

AASP Webpage

Archeology and Paleoecology

Q: How did Easter Islanders move and erect giant statues? Why did their society collapse?

Archeology and Paleoecology

A: The island was once covered by giant palm trees which were used as sleds and levers.
Deforestation destroyed their society.

Unconformity

A buried surface of erosion

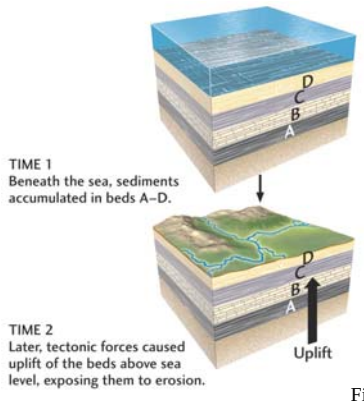


Fig. 8.6

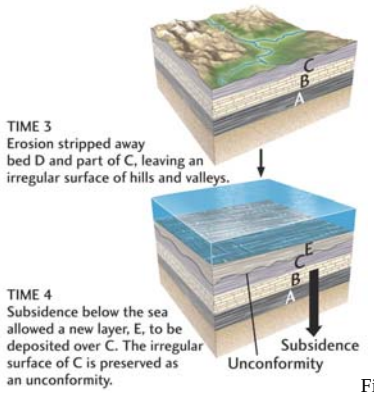


Fig. 8.6

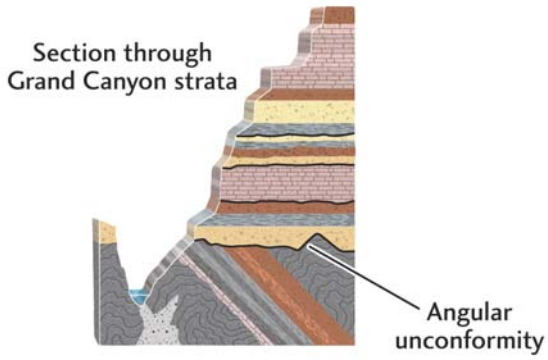


Fig. 8.7

Fig. 8.7

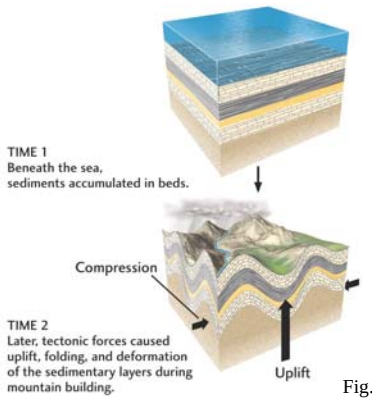


Fig. 8.8

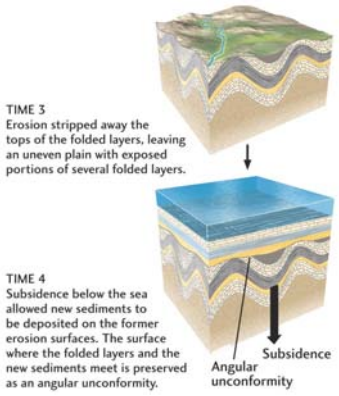


Fig. 8.8

Cross-cutting Relationships

- Geometry of rocks that allows geologists to place rock unit in relative chronological order.
- Used for relative dating.

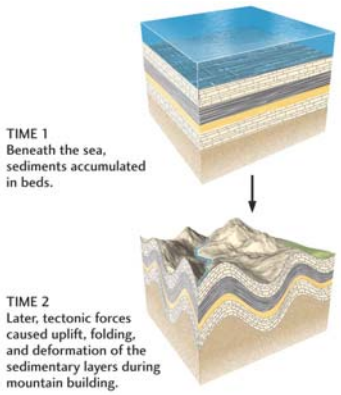


Fig. 8.10

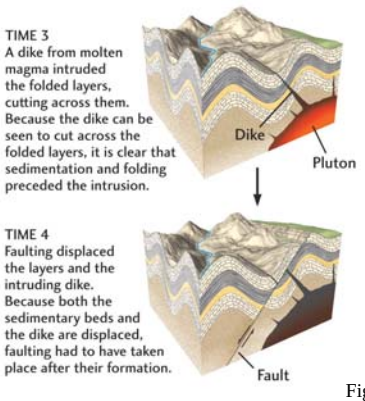


Fig. 8.10

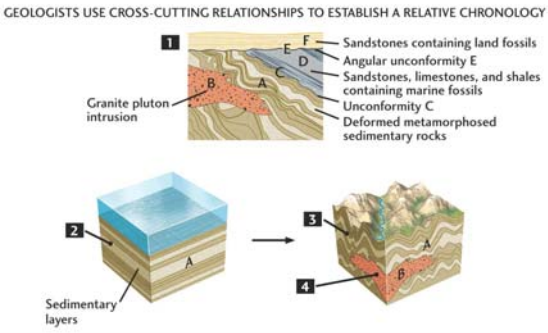


Fig. 8.10

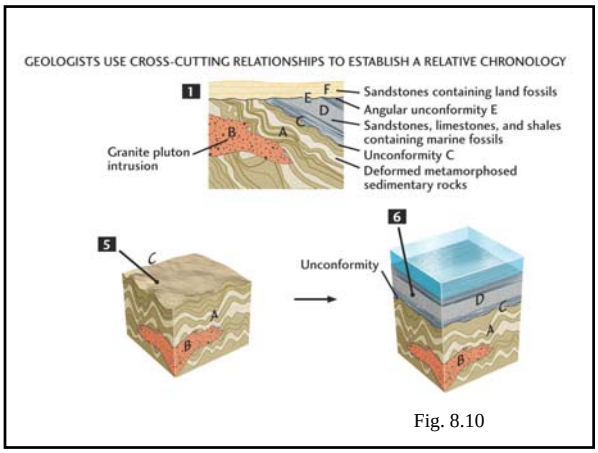


Fig. 8.10

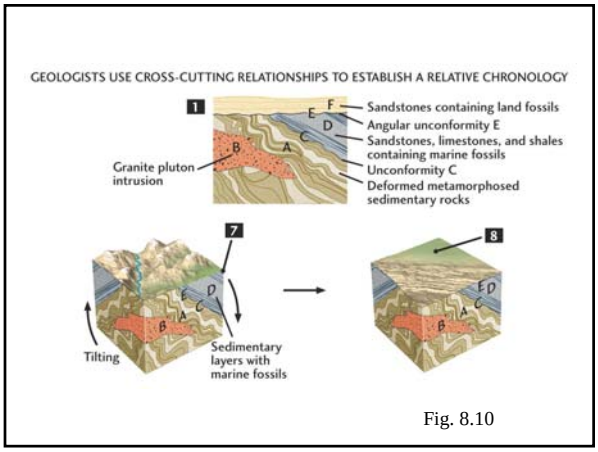


Fig. 8.10

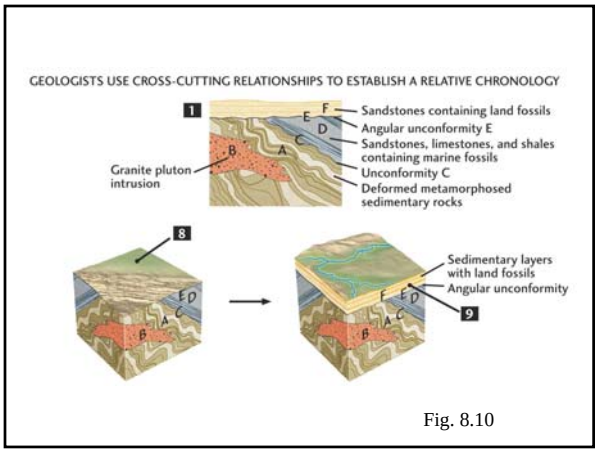
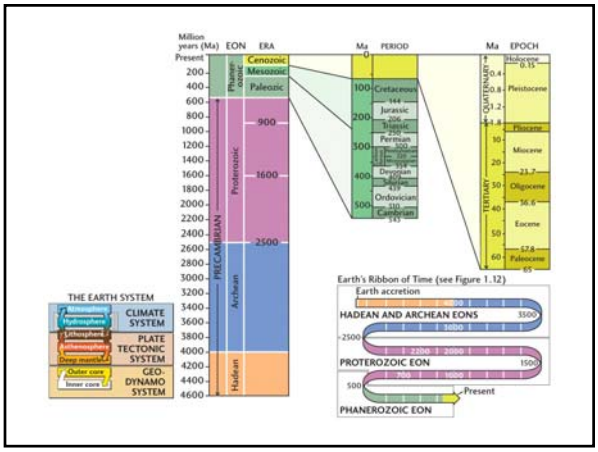
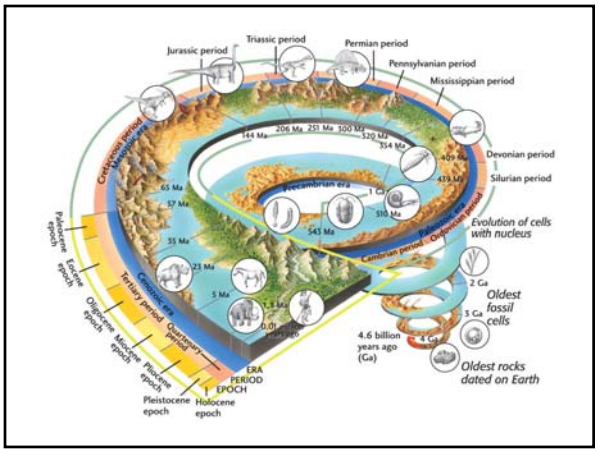


Fig. 8.10

The Geologic Timescale

Divisions in the worldwide stratigraphic column based on variations in preserved fossils





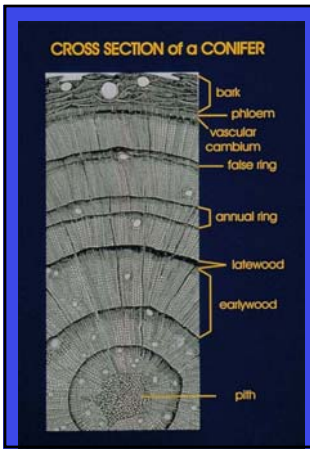
Absolute Geochronology

- Add numbers to the stratigraphic column based on fossils
- Based on the regular radioactive decay of some chemical elements

Dendrochronology or tree-ring dating

A method of scientific dating based on growth rings.

Tree rings provide a record of local climate during the life of the tree



New growth rings are generated just under the bark (vascular cambium)

Each annual ring consists of earlywood and latewood

Earlywood thin walled, low in density and light in color

Latewood is thick walled and dark in color (less favorable growing conditions)

http://www.ncdc.noaa.gov/paleo/treering.html

Dating Trees

Counting the Rings gives the age of the tree

Variations in thickness of rings and variations in thickness of earlywood and latewood and color give information on climate (temperature and rainfall)

Changes in Climate

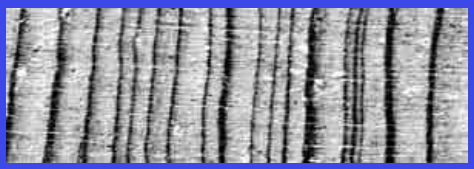
Douglas Fir from Arizona

550 mark is 550 AD

Note change in ring thickness from center to edge

http://web.utk.edu/~grissino/gallery.htm#Rings

Variations in Adjacent Rings Creates a Unique Pattern



variation in total ring width: a light and a dark band
variation in latewood width: just the dark bands
variation in latewood density: darkness of dark band

UPC Bar Code

http://www.barcodesinc.com/generator/index.php

Isotopes

Atoms of elements with the same number of protons and varying numbers of neutrons

Examples:

^{235}U, ^{238}U ^{87}Sr, ^{86}Sr ^{14}C, ^{12}C

Isotopic Dating

- Radioactive elements (parents) decay to stable, non-radioactive elements (daughters)
- The rate at which this decay occurs is constant and known
- If we know the rate of decay and the amount present of parent and daughter we can calculate how long this reaction has been occurring.

Types of Decay

- **alpha decay: loss of a ^{4}He (2n, 2p)**
  e.g., $^{147}Sm \rightarrow {}^{143}Nd$
- **beta decay: neutron → proton**
  e.g., $^{87}Rb \rightarrow {}^{87}Sr$
- **electron capture: proton → neutron**
  e.g., $^{40}K \rightarrow {}^{40}Ar$

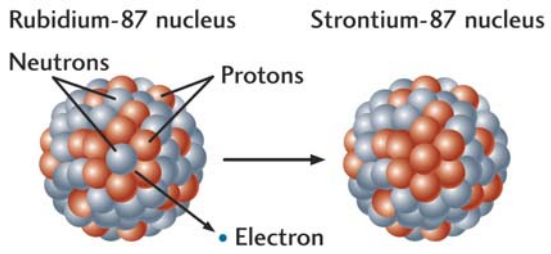


Fig. 8.12

Requirements for Isotopic Dating

- Closed system
- decay rate constant
- Initial concentration of daughter is known (zero is best)

Half-life

The half-life of a radioactive isotope is defined as the time required for half of it to decay.

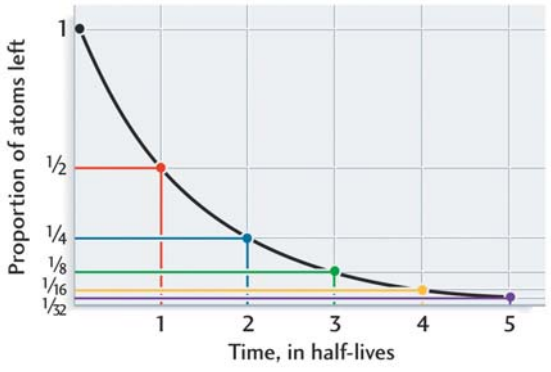


Table 10.1 Major Radioactive Elements Used in Radiometric Dating

Isotopes		Half-Life of Parent (years)	Effective Dating Range (years)	Minerals and Materials That Can Be Dated
Parent	Daughter			
Uranium-238	Lead-206	0.7 billion	10 million–4.6 billion	Zircon Apatite
Uranium-235	Lead-207	4.5 billion	10 million–4.6 billion	Zircon Apatite
Potassium-40	Argon-40	1.3 billion	50,000–4.6 billion	Muscovite Biotite Hornblende
Rubidium-87	Strontium-87	47 billion	10 million–4.6 billion	Muscovite Biotite Potassium feldspar
Carbon-14	Nitrogen-14	5730	100–70,000	Wood, charcoal, peat Bone and tissue Shell and other calcium carbonate Groundwater, ocean water, and glacier ice containing dissolved carbon dioxide